

REMARKS

Claims 28-30 have been cancelled without prejudice, claims 1, 2, 4, 5, 21, 22 and 35 amended and newly written claims 42 and 43 offered for consideration. Accordingly, claims 1-27 and 31-43 remain in this application.

Attached hereto is a marked-up version of the changes made to the specification and claim(s) by the current amendment. The attached page(s) is captioned "**Version With Markings To Show Changes Made.**"

The Examiner's acknowledgment that the drawings filed September 19, 2001 are acceptable is very much appreciated. Additionally, the Examiner's acknowledgment of applicant's claim for priority and receipt of the certified copy of the priority document is also appreciated.

Claims 10-13 and 27-30 stand rejected under 35 USC §112 (first paragraph), with the Examiner alleging that the specification is "not enabling" for using InP substrates and InGaAsP or AlGaAs quantum layers and barrier layers. The Examiner is believed to be incorrect in his assessment. The Examiner's attention is directed to the Brief Description of the Drawings and in particular Figure 1 which is indicated as being a disclosure relating to an InP substrate with InGaAsP as a barrier and Figure 6 discloses AlGaAs as a quantum well cell. The Examiner's attention is also directed towards the discussions of these figures in applicant's specification as originally filed. How or why the Examiner does not believe these substrates, quantum well layers and barrier layers are not supported by applicant's specification is not understood and clarification requested.

If the Examiner's contention is that the specification is not enabling for other materials as "substrates or strontium-containing layers," this is also respectfully traversed. Examples of strontium-containing layers are disclosed in the discussion of Table 3 and in Table 3 itself on page 9 of applicant's specification. Moreover, those having ordinary skill in the art will understand that the general relationships needed for strain compensation with zero stress are disclosed in detail on pages 11 and 12 of the present specification. It is well known to those of ordinary skill in the art that, in view of these disclosed relationships, one would be able to apply the strain compensation feature of the present invention to numerous material systems, thereby obviating the need for applicant to disclose each and every possible combination of elements used in photovoltaic cells.

The Examiner also suggests that the specification does not describe the use of other materials as substrates other than InP. Again, this contention is respectfully traversed. The discussion of Figure 1 on page 4 suggests a substrate of InGaAs and Figures 3 and 4 discuss bulk GaSb and on page 11 virtual substrates of InAsP and InGaAs are also disclosed.

Additionally, the Examiner suggests that InGaAsP is the only material disclosed in depth for quantum well and material layers. While in one embodiment of applicant's invention this is the preferred material, the Examiner appears to concede that numerous other materials are disclosed, but possibly not "in depth." There is no requirement in 35 USC §112 (first paragraph) for an "in depth" disclosure in order to meet the first

paragraph requirements. As a result, the Examiner's contention that InGaAsP is the only material for quantum well and barrier layers is respectfully traversed.

The Examiner observes that in Figure 6 the dark current behavior of a QWC (quantum well cell) is shown, but no details of the cell are disclosed. Again, the disclosure requirement of the first paragraph of §112 is not to provide a detailed disclosure of every possible embodiment of applicant's invention. Rather, the disclosure requirement is to provide an enabling disclosure of at least one embodiment and sufficient disclosure such that those of ordinary skill in the art can practice the claimed invention, without undue experimentation. The Examiner has not provided any reasonable basis for concluding that one of ordinary skill in the art could not practice applicant's claimed invention in view of the disclosure as originally submitted.

Should the Examiner maintain this "non-enablement" rejection, he is respectfully requested to point out which specific claims are alleged not to be supported in applicant's specification and which would not be supported in the specification by one of ordinary skill in the art reading the originally filed specification.

Claims 28-30 stand rejected under 35 USC §112 (first paragraph) as containing subject matter not described in the specification. Applicant has cancelled without prejudice claims 28-30, thereby obviating the rejection.

Claims 1-17, 19, 20, 21-26, 28-30, 32, 34, 35 and 41 stand rejected under 35 USC §112 (second paragraph) as being indefinite. The Examiner objects to claims 1, 6, 17, 19, 23, 32, 34 and 41 as being indefinite because they contain limitations reciting the term

"substantially." The Examiner suggests that the term "substantially" be deleted from the claims. The Examiner's contention that the word "substantially" renders any claim indefinite under 35 USC §112 is respectfully traversed.

The Examiner's attention is directed to the Manual of Patent Examining Procedure (MPEP) and specifically to Section 2173.05(b) thereof relating to "Relative Terminology" and specifically to subsection (d) thereunder. The heading of this subsection is "substantially," with the MPEP indicating that this word "is often used in conjunction with another term to describe a particular characteristic of the claimed invention." Three cases (two by the Court of Customs and Patent Appeals and one by the Federal Circuit) describe that the use of the word "substantially" is definite.

There is no case cited in the MPEP which suggests that the word "substantially" is violative of the definiteness requirements of 35 USC §112. Should the Examiner be of the opinion that there is any Federal Circuit case law supporting his contention that this word is "indefinite," he is respectfully requested to point out such decisions.

Moreover, applicant uses the term because it is well known to those of ordinary skill in the art in the creation of photovoltaic devices that minor variations do not render a combination of structures inoperative. While they may affect the overall efficiency, minor variations in the shear force, compressive or tensile strained layers or in concentration of various dopants of layers will not render the claimed devices inoperative. Accordingly, the word "substantially" is used in applicant's claims to indicate that while the "substantially" claimed feature should be close to the stated

limitation, it does not have to be exactly the stated limitation in order for the device to be operative and to fall within the scope of the claimed invention. As a result, reconsideration of the Examiner's objection to the use of the word "substantially" is respectfully requested.

Claims 2 and 35 stand objected to with respect to the language "the same lattice constant as a substrate" as lacking antecedent basis. Claims 2 and 35 have been amended to provide proper antecedent basis for the recitation.

Claims 4, 5, 21 and 22 are alleged to be indefinite. These claims have been amended to make definite that the barrier has a lattice constant not equal to the substrate lattice constant, thereby obviating any further objection.

Claims 21 and 22 also stand objected to as lacking insufficient antecedent basis for the limitation in the claims. The dependency of claims 21 and 22 has been changed from claim 18 to claim 20 which recites the existence of tensile and compressively strained layers, thereby providing the necessary antecedent basis. Claim 24 depends from claim 21 and therefore now also has proper antecedent basis.

As noted above, claims 38-30 have been cancelled without prejudice, thereby obviating any objections.

In view of the above, it is submitted that there is no remaining basis for rejection of claims 1-17, 19-26, 28-30, 32, 34, 35 and 41 under 35 USC §112 and any further rejection thereunder is respectfully traversed.

Claims 1-6, 12 and 13 stand rejected under 35 USC §102 as being anticipated by Ekins-Daukes I ("Strain-Balanced . . ."). It is clear that the Ekins-Daukes I article addresses the problem of lattice mismatch, but places an upper limit on the number of quantum wells which can be utilized ("[h]owever, the lattice mismatch places an upper limit on the number of QWs that can be accommodated before strain relaxation takes place. . ."). Ekins-Daukes I teaches overcoming this problem by providing quantum wells where the compressive strain and tensile strain of the wells overcome the lattice-mismatch limitations, and the dimensions are chosen so as to ensure the average lattice parameter across the i-region to be equal to that of GaAs.

Thus, Ekins-Daukes I uses an average lattice parameter which is significantly different from the claimed invention of using strain compensation such that substantially no shear force is exerted on neighboring structures. The Examiner's attention is directed to the relationships outlined on pages 11 and 12 of the present specification which clearly differentiate the claimed strain compensation technique for that described in the Ekins-Daukes I article. The claimed invention permits those of ordinary skill in the art to fabricate high quality (dislocation free) material with highly strained layers. Thus, while Ekins-Daukes I recognizes a portion of the problem solved by applicant's invention, he suggests a completely different solution from that recited in applicant's claims. How or why the Examiner believes that applicant's claimed solution, as set out in claim 1 or in claims dependent thereon, is taught or suggested in the Ekins-Daukes I reference is not seen and clarification requested.

It is noted that applicant has rewritten claim 1 to be more in consistence with U.S. claim drafting practice and to more positively recite the subject matter of applicant's claimed invention. Consideration of amended claim 1 and the claims dependent thereon is respectfully requested.

Claims 1-5, 7, 16 and 17 stand rejected under 35 USC §102 as being anticipated by Rohr et al. The Rohr et al disclosure is applicant's own publication published less than a year before applicant's priority date of UK application 118150.2 filed July 25, 2001. The similarity between drawings in the Rohr reference and applicant's specification should be noted. If the Examiner believes a declaration from the inventors as to the non-inventorship of authors of the Rohr et al article who are not named as inventors in the present application, such a declaration can and will be prepared.

Claims 1-6 and 1-14 stand rejected under 35 USC §102 as being anticipated by Ekins-Daukes II ("Strained and strain-balanced . . ."). Again, this document is unavailable as a reference against the present application in that it was published in 2001 and clearly less than a year before applicant's priority date of July 25, 2001. Again, the similarity of this disclosure to the present invention is noted in the various figures. In the event the Examiner requires a declaration from the inventors of the present invention with respect to the non-inventor authors of the Ekins-Daukes II reference, one can and will be submitted.

Claims 7-11, 14 and 15 stand rejected under 35 USC §103 as unpatentable over Ekins-Daukes I in view of Freundlich I (U.S. Patent 5,851,310). The above comments

with respect to Ekins-Daukes I are herein incorporated by reference. Because Ekins-Daukes I would lead one of ordinary skill in the art away from applicant's claimed invention, its combination with Freundlich would still lead one of ordinary skill in the art away from applicants' claimed combination of elements.

Claims 16 and 17 stand rejected under 35 USC §103 as unpatentable over Ekins-Daukes I in view of Freundlich II (U.S. Patent 6,150,604). The above comments regarding the Ekins-Daukes I reference are herein incorporated by reference. Because Ekins-Daukes I would lead one of ordinary skill in the art away from applicants' invention, the combination with Freundlich II would also lead one of ordinary skill in the art away from applicants' claimed invention.

Claims 18, 21-23 and 25-27 stand rejected under 35 USC §103 as unpatentable over Freundlich I. The Examiner contends that Freundlich I teaches a relaxed buffer layer, thereby rendering obvious the same in applicants' claims. Applicants point out that not all relaxed buffers work as a good virtual substrate. In particular, although a relaxed buffer layer can easily provide a suitable lattice parameter for subsequent lattice-matched growth of a device structure, it is extremely difficult to obtain a mechanically stable structure that prevents or at least impedes any dislocations generated in a buffer layer from propagating into the active region of the overgrown device.

As set forth in applicants' claim 18 and claims dependent thereon, the recipe for the substrate claimed has not been disclosed or suggested by anyone, but offers a surprisingly effective virtual buffer due to its low number of dislocations. Freundlich I

does not address the problem of thread dislocations, nor does it disclose a virtual substrate as set out in claim 18. Should the Examiner be of the opinion that it does, he is respectfully requested to point out where Freundlich I teaches the virtual substrate of $\text{InP}_{1-x}\text{As}_x$, where zero is less than X which is less than one. Barring such disclosure, claim 18 is clearly not obvious in view of Freundlich I.

Claims 19, 20 and 24 stand rejected under 35 USC §103 as unpatentable over Freundlich I and Ekins-Daukes I. The above comments with respect to Ekins-Daukes I and Freundlich I are herein incorporated by reference. The Examiner's admissions that Freundlich I does not disclose numerous claimed structures is very much appreciated. Because the Ekins-Daukes I and Freundlich I references both teach away from applicants' claimed invention, the Examiner has not indicated how or why one of ordinary skill in the art would seek to modify these two references in the manner of applicants' claims.

Claims 31-33 and 36-41 stand rejected over Freundlich I in view of Freundlich II. The above comments with respect to Freundlich I and Freundlich II are herein incorporated by reference. The Examiner's admissions that Freundlich I does not disclose the various features of applicants' claims is very much appreciated. The Examiner has not pointed out how or where Freundlich II discloses these missing features or where there is any reason for combining the teachings of Freundlich I and Freundlich II. Moreover, it has been previously noted that these references clearly would lead one of ordinary skill in the art away from applicants' invention, and the Examiner has simply failed to meet his burden of establishing a *prima facie* case of obviousness.

Claims 34 and 35 stand rejected under 35 USC §103 as unpatentable over Freundlich I in view of Freundlich II and further in view of Ekins-Daukes I. The above comments with respect to Freundlich I, Freundlich II and Ekins-Daukes I are herein incorporated by reference. The Examiner's admissions that Freundlich I and Freundlich II do not disclose features of these rejected claims is very much appreciated. However, the Examiner has failed to provide any indication of how Ekins-Daukes I discloses the missing features or why one of ordinary skill in the art would pick and choose various features from the three references and combine them in the manner of applicants' claims. Failure to provide a reason or motivation for combining references is an indication that the Office has failed to meet the burden of establishing a *prima facie* case of obviousness.

Having responded to all objections and rejections set forth in the outstanding Official Action, it is submitted that remaining claims 1-27 and 31-43 are in condition for allowance and notice to that effect is respectfully solicited. In the event the Examiner is of the opinion that a brief telephone or personal interview will facilitate allowance of one or more of the above claims, he is respectfully requested to contact applicant's undersigned representative.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE
IN THE CLAIMS

1. (Amended) A photovoltaic device [having] comprising:
a plurality of [multiple] quantum wells [portion with] and
a plurality of barriers, said barriers alternating with said quantum wells, one of
said plurality of quantum wells and said plurality of barriers comprised of [alternating]
tensile strained layers and the other of said plurality of quantum wells and said plurality
of barriers comprised of compressively strained layers, said tensile strained layers and
said compressively strained layers having compositions such that a period of one tensile
strained layer and one compressively strained layer exerts substantially no shear force on
a neighbouring structure.
2. (Amended) A photovoltaic device as claimed in claim 1, wherein said
neighbouring structure is one of:
a further period of one tensile strained layer and one compressively strained layer;
a layer of arbitrary doping having [the same] a lattice constant [as a substrate]; and
a substrate having a lattice constant, wherein said arbitrary doping layer lattice
constant is substantially the same as said substrate lattice constant.
4. (Amended) A photovoltaic device as claimed in claim 3, wherein at least one of
said tensile strained layers or said compressively strained layers is a quantum well having

a lattice constant not equal to said substrate lattice constant and having a Group III/V semiconductor composition with a bandgap lower than if said quantum well had a lattice constant equal to said substrate lattice constant.

5. (Amended) A photovoltaic device as claimed in claim 3, wherein at least one of said tensile strained layers or said compressively strained layers is a barrier having a lattice constant not equal to said substrate lattice constant and a Group III/V semiconductor composition with a bandgap higher than if said barrier had a lattice constant equal to said substrate lattice constant.

21. (Amended) A photovoltaic device as claimed in claim 18, wherein at least one of said tensile strained layers or said compressively strained layers is a quantum well having a lattice constant not equal to said substrate lattice constant and a Group III/V semiconductor composition with a bandgap lower than if said quantum well had a lattice constant equal to said substrate lattice constant.

22. (Amended) A photovoltaic device as claimed in claim 18, wherein at least one of said tensile strained layers or said compressively strained layers is a barrier having a lattice constant not equal to said substrate lattice constant and a Group III/V

semiconductor composition with a bandgap higher than if said barrier had a lattice constant equal to said substrate lattice constant.

35. (Amended) A photovoltaic device as claimed in claim 34, wherein said neighbouring structure is one of:

a further period of one tensile strained layer and one compressively strained layer;
a layer of arbitrary doping having [the same] a lattice constant [as a substrate]; and
a substrate having a lattice constant, wherein said arbitrary doping layer lattice
constant is substantially the same as said substrate lattice constant.

--42. (New) A photovoltaic device as claimed in claim 1, wherein said quantum wells comprise said compressively strained layers.

43. (New) A photovoltaic device as claimed in claim 1, wherein said barriers comprises said tensile strained layers. --